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Date	Status	Code	Description
07/30/2003		FWDX	DATE FORWARDED TO EXAMINER
07/23/2003	71	RCEX	REQUEST FOR CONTINUED EXAMINATION (RCE)
07/30/2003		ABN9	EXPRESS ABANDONMENT (FOR ENTRY OF CPA / RCE / RULE12
07/23/2003		XT/G	REQUEST FOR EXTENSION OF TIME - GRANTED
07/23/2003		BRCE	WORKFLOW - REQUEST FOR RCE - BEGIN
07/11/2003	83	MCTAV	MAIL ADVISORY ACTION (PTOL - 303)
07/10/2003	82	CTAV	ADVISORY ACTION (PTOL-303)
07/01/2003		FWDX	DATE FORWARDED TO EXAMINER
06/25/2003	80	A.NE	AMENDMENT AFTER FINAL REJECTION
06/25/2003		XT/G	REQUEST FOR EXTENSION OF TIME - GRANTED
05/29/2003	83	MCTAV	MAIL ADVISORY ACTION (PTOL - 303)
05/29/2003	82	CTAV	ADVISORY ACTION (PTOL-303)
05/23/2003		FWDX	DATE FORWARDED TO EXAMINER
05/20/2003	80	A.NE	AMENDMENT AFTER FINAL REJECTION
05/06/2003	83	MCTAV	MAIL ADVISORY ACTION (PTOL - 303)
05/05/2003	82	CTAV	ADVISORY ACTION (PTOL-303)
04/25/2003		FWDX	DATE FORWARDED TO EXAMINER
04/23/2003	80	A.NE	AMENDMENT AFTER FINAL REJECTION
04/23/2003		LTDR	INCOMING LETTER PERTAINING TO THE DRAWINGS
02/25/2003	61	MCTFR	MAIL FINAL REJECTION (PTOL - 326)
02/21/2003	60	CTFR	FINAL REJECTION
12/18/2002		FWDX	DATE FORWARDED TO EXAMINER

L Number	Hits	Search Text	DB	Time stamp
-	16690	"recording head".ti.	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/09/29 17:58
-	7306	"recording head".ti. and jet	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/09/29 17:58
-	141	("recording head".ti. and jet) and (chamber or pool or reservoir).detd. and nozzle.detd. and mask.detd.	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/09/29 17:58
-	307594	"99" and @py<2000	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/09/29 17:58
-	173	("recording head".ti. and jet) and nozzle.detd. and mask.detd.	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/09/29 17:58
-	39772	"recording head".ti. or "recording head".ab.	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/09/29 17:58
-	196	("recording head".ti. or "recording head".ab.) and (chamber or pool).detd. and nozzle.detd. and mask.detd.	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/09/29 17:58
-	205	("recording head".ti. or "recording head".ab.) and (chamber or pool or reservoir).detd. and nozzle.detd. and mask.detd.	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/09/29 17:58
-	90	((("recording head".ti. or "recording head".ab.) and (chamber or pool or reservoir).detd. and nozzle.detd. and mask.detd.) not ((("recording head".ti. or "recording head".ab.) and (chamber or pool or reservoir).detd. and nozzle.detd. and mask.detd.) and (silica or 'sio.sub.2') and (sin or "silicon nitride"))) and "<110>"	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/09/29 17:58
-	255	(("recording head" or "recording head") same "ink jet") and (chamber or pool or reservoir).detd. and nozzle.detd. and mask.detd. and (silicon or si)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/09/29 17:58
-	4878	(chamber or pool or reservoir or bath).detd. and nozzle.detd. and mask.detd.	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/09/29 17:58
-	1690	((chamber or pool or reservoir or bath).detd. and nozzle.detd. and mask.detd.) and "ink jet"	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/09/29 17:58
-	1224	(((chamber or pool or reservoir or bath).detd. and nozzle.detd. and mask.detd.) and "ink jet") and (etch or etching or etched or etches or etching)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/09/29 17:58

-	307	((((chamber or pool or reservoir or bath).detd. and nozzle.detd. and mask.detd.) and "ink jet") and (etch or etching or etched or etches or etching)) and '110' and '111'	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/09/29 17:58
-	138	("recording head".ti. and jet) and (chamber or pool).detd. and nozzle.detd. and mask.detd.	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/09/29 17:59
-	38	(("recording head".ti. and jet) and (chamber or pool).detd. and nozzle.detd. and mask.detd.) and @py<2000	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/09/29 17:59
-	38	(("recording head".ti. and jet) and (chamber or pool or reservoir).detd. and nozzle.detd. and mask.detd.) and @py<2000	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/09/29 17:59
-	6	((("recording head".ti. and jet) and (chamber or pool or reservoir).detd. and nozzle.detd. and mask.detd.) and @py<2000) and (silica or 'sio.sub.2') and (sin or "silicon nitride")	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/09/29 17:59
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-	157	(("recording head".ti. or "recording head".ab.) and (chamber or pool or reservoir).detd. and nozzle.detd. and mask.detd.) not ((("recording head".ti. or "recording head".ab.) and (chamber or pool or reservoir).detd. and nozzle.detd. and mask.detd.) and (silica or 'sio.sub.2') and (sin or "silicon nitride"))	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/09/29 17:59
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-	8	("recording head".ti. or "recording head".ab.) and (chamber or pool or reservoir).ti. and nozzle.detd. and mask.detd.	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/09/29 17:59
-	59	(("recording head".ti. or "recording head".ab.) and (chamber or pool or reservoir).detd. and nozzle.detd. and mask.detd. and (silicon or si)) and '110' and '111'	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/09/29 17:59
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-	6	((("recording head" or "recording head") same "ink jet") and (chamber or pool or reservoir).detd. and nozzle.detd. and mask.detd. and (silicon or si)) and (comb or ladder).detd.	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/09/29 17:59
-	102	("recording head" same "ink jet").detd. and (comb or ladder).detd.	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/09/29 17:59

-	16	(("recording head" same "ink jet").detd. and (comb or ladder).detd.) and mask	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/09/29 17:59
-	2	(("6273558") or ("5381171")).PN.	USPAT	2003/09/29 17:59
-	3	(("5992974") or ("5992974")).PN.	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/09/29 17:59
-	2	us-20010004805-$.did.	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/09/29 17:59
-	5	(US-5984458-$ or US-5922218-$ or US-5578417-$ or US-5502470-$ or US-5126768-$).did.	USPAT	2003/09/29 18:02
-	222	("recording head".ti. or "recording head".ab.) and (118/715.ccls. or 156/345.29.ccls. or 216/67.ccls. or 347/45.ccls. or 347/65.ccls. or 347/68.ccls. or 216/72.ccls.)	USPAT	2003/09/29 18:04

FIG. 7(*a*) is a plan view of a nozzle plate according to a third embodiment of the present invention, and FIG. 7(*b*) is a cross-sectional view taken along line C—C shown in FIG. 7(*a*);

FIG. **8** is a cross-sectional view of an ink-jet recording head according to a fourth embodiment of the present invention; and

FIG. **9** is a perspective view of one example of a conventional nozzle plate which uses a silicon monocrystalline substrate.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The details of the present invention will be described hereinbelow with reference to an illustrative embodiment.

Throughout the following descriptions of the embodiment, a lattice face will be herein described as (110), a lattice orientation as <110>, and a unit cell of 1 bar as -1.

FIGS. 1(*a*) and 1(*b*) show a first embodiment of the an ink-jet recording head according to the present invention. In the drawings, reference numeral **1** designates a spacer. In the present embodiment, the spacer **1** is formed by anisotropically etching a silicon monocrystalline substrate with a lattice face (110) so as to constitute ink cavities **2**, an ink reservoir **3**, and ink supply ports **4**.

One side of the spacer **1** is sealed with a cover member **5** which will be described later, whereas the other side is sealed with a nozzle plate **6** which is a feature of the present invention. Ink droplets are discharged from nozzle openings **7** as a result of the generation of pressure in the ink cavities **2**.

As in the present embodiment, piezoelectric elements **8** can be used as the pressure generating elements. They are disposed on, while remaining in contact with, the top of the cover member **5** so as to be opposite to the respective ink cavities **2**. In the case where an inelastically deformable material is used for the pressure generating element, Joule's heat generating elements can be housed in the ink cavities **2**.

In the drawing, the nozzle plate **6** which is a feature of the present invention comprises the nozzle openings **7** arrayed at constant pitches which are formed by anisotropically etching the silicon monocrystalline substrate with the face (110) which will be described later. In the case where the nozzle openings **7** are formed by anisotropically etching the silicon monocrystalline substrate with the face (110), the nozzle openings are formed in the shape of recesses consisting of a face **10**, a face **11**, a face **12**, and a face **13**. Further, a cylindrical portion **7***a* suitable for discharging ink droplets is formed on the discharge side of the discharge orifice by using isotropic etching in combination with anisotropic etching.

FIG. **2** is an enlarged view showing the vicinity of the nozzle openings. Both the faces **10** and **11** intrinsically appear as a natural result of the anisotropic etching of the silicon monocrystalline substrate with the face (110). The face **10** is a face (1-11) normal to the (110) face of the silicon monocrystalline substrate, whereas the face **11** is a face (1-11) normal to a face (-11-1) which is equivalent to the face **10**, namely, the (110) face of the silicon monocrystalline substrate.

The face **12** is a (111) plane which appears at an angle of about 35° with respect to the (110) face of the silicon monocrystalline substrate. Similarly, the face **13** is a face (11-1) which appears at an angle of 35° with respect to the (110) face of the silicon monocrystalline substrate. The faces (1-11), (-11-1), (1-1-1), and (-111) normal to the face (110) will be hereinafter simply referred to as a vertical (111) face. Moreover, faces (111) and (11-1), which come about at an angle of about 35° with respect to the face (110), will be hereinafter simply referred to as a face (111) at an angle of 35°.

Of the four side faces which form the recess, the two faces **10** and **11** which are opposite to each other are orthogonal to the surface of the silicon monocrystalline substrate. Therefore, there will be very little chance of the recess extending at least in a horizontal direction, that is, in the direction parallel to the surface of the silicon monocrystalline substrate irrespective of the progress of the etching operation. A pitch W between the faces **10** and **11** becomes constant irrespective of the thickness of the silicon monocrystalline substrate, namely, it becomes equal to the size defined by a protecting film used in the anisotropic etching operation.

For these reasons, a mask of the nozzle openings **7** is formed such that the nozzle openings are arrayed in the direction in which the faces **10** and **11** are opposite to each other, and then the substrate covered with the mask is anisotropically etched. As a result, the nozzle openings **7** can be formed in the silicon monocrystalline substrate having a thickness which is easy to handle, without decreasing the pitch of the nozzle openings **7**.

The faces **12** and **13** adjoining the vertical faces **10** and **11** are held at an angle of about 35° with respect to the surface of the silicon monocrystalline substrate. The boundary of the etched side of the substrate, that is, the wider side of the recess, becomes further away from the center as the anisotropic etching progresses, thereby increasing a distance L. The length L is in the longitudinal direction of the cavity **2**, and therefore an increase in the distance L does not substantially affect the pitch of the nozzle openings **7**.

Needless to say, the nozzle openings **7** can be formed in the same manner by use of other silicon monocrystalline substrates having faces (-110), (1-10), and (-1-10) on their surfaces which show the same etching characteristics as the silicon monocrystalline substrate having the face (110) on its surface.

In the present embodiment, if the ink cavities **2** filled with ink are pressurized by deforming the pressure generating means, for example, the piezoelectric elements **8** disposed on the cover member **5** which constitutes part of the ink cavities **2**, the pressure in the cavities **2** is increased, whereby the ink is discharged from the nozzle openings **7**.

As a result of a drop in the pressure of the ink cavities **2**, the ink in the ink reservoir **3** is fed to the ink cavities **2** through the ink supply ports **4**, and the ink cavities **2** are filled with the ink in preparation for the next discharging operation.

One embodiment of a method of manufacturing the ink-jet head according to a present invention will be described with reference to FIGS. 3(*a*) to 3(*j*).

Silicon dioxide layers **21** and **22** are formed to a thickness of about 1μm on the respective sides of a silicon monocrystalline substrate **20** having a thickness which makes the nozzle plate **6** easy to handle, for example, a thickness of 140 μm, by thermal oxidation (FIG. 3(*a*)). These silicon oxide layers **21** and **22** laid on the respective sides of the silicon monocrystalline substrate serve as an etching mask when the silicon monocrystalline substrate **20** is etched.

Patterns best suitable for use as a nozzle, e.g., circular patterns **24**, are patterned on one surface of the silicon monocrystalline substrate **20** where the nozzle openings **7**

FIG. 2A

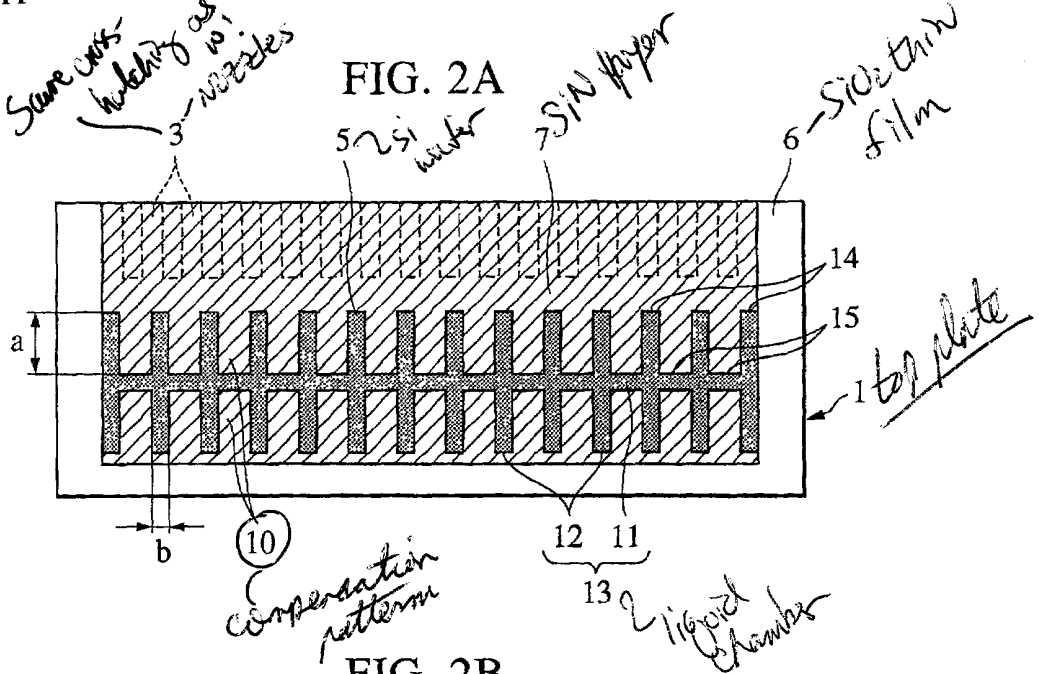

FIG. 2B

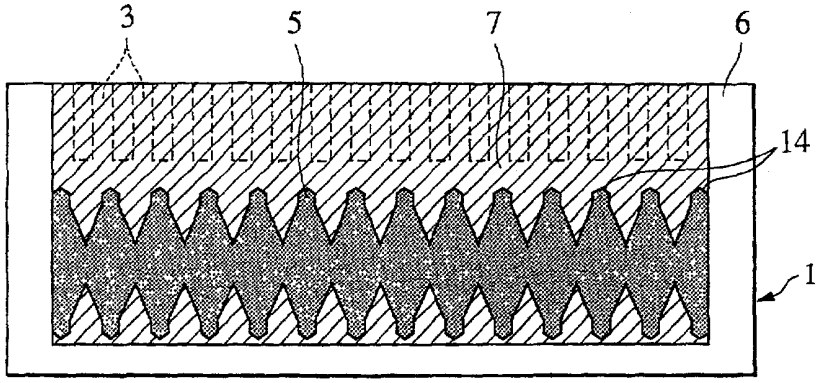

FIG. 2C

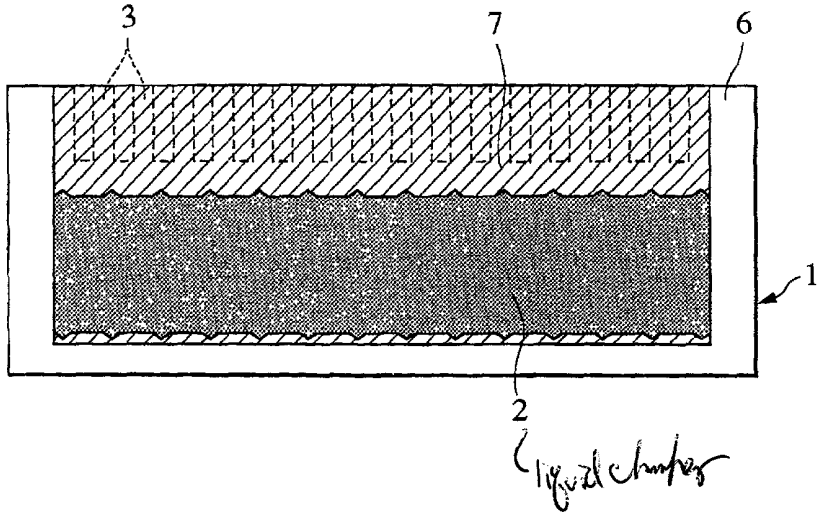

FIG. 2

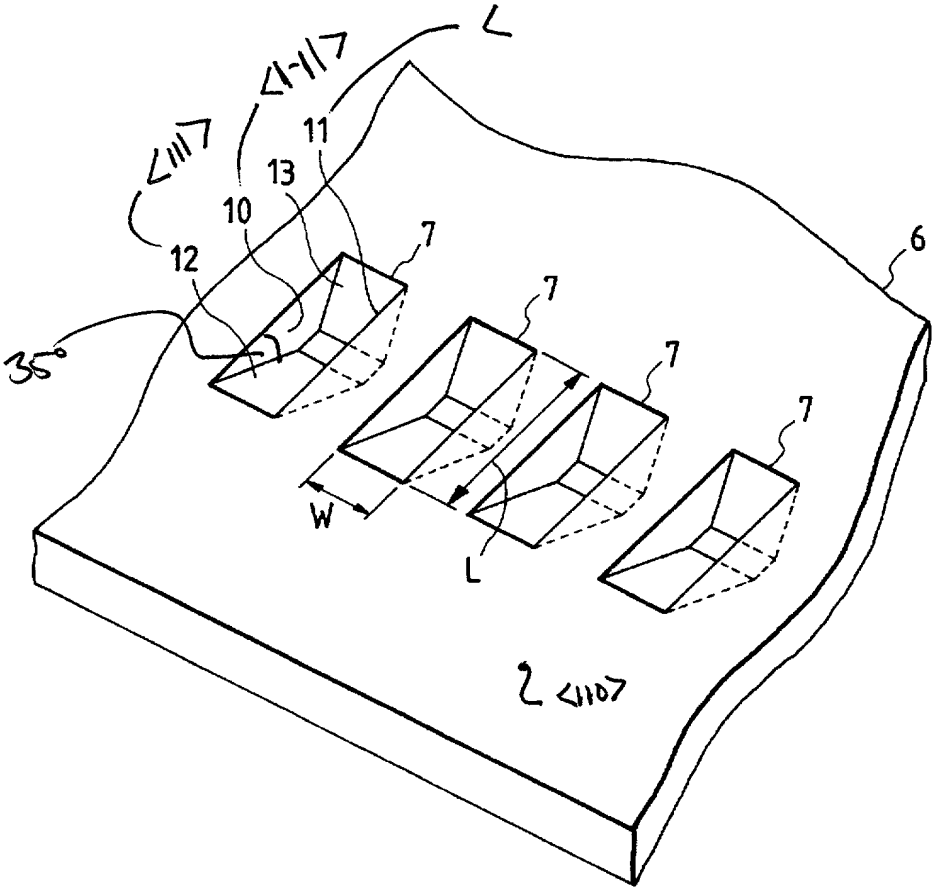

FIG. 4

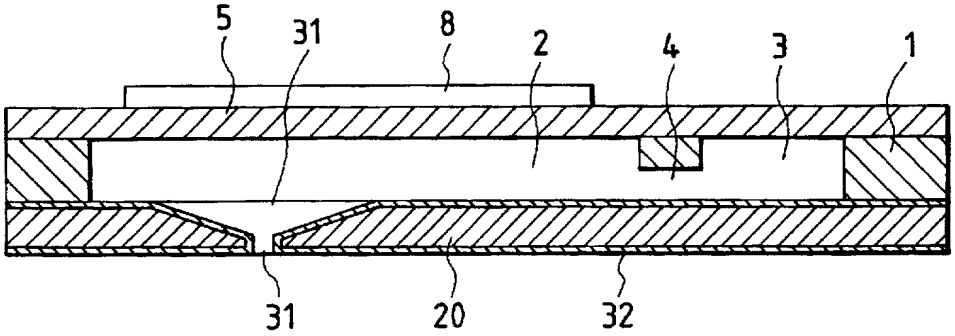

FIG. 5(a)

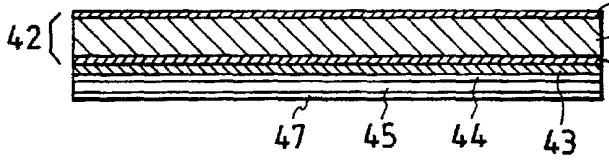

FIG. 5(b)

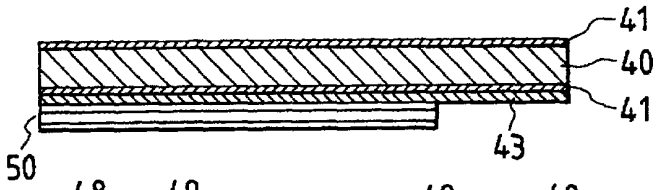

FIG. 5(c)

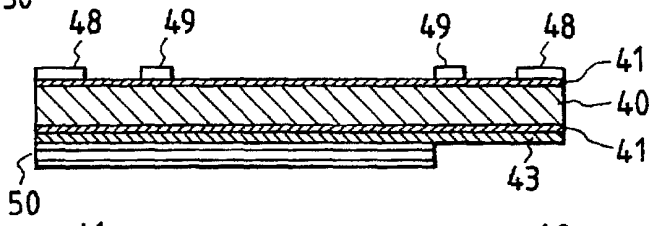

FIG. 5(d)

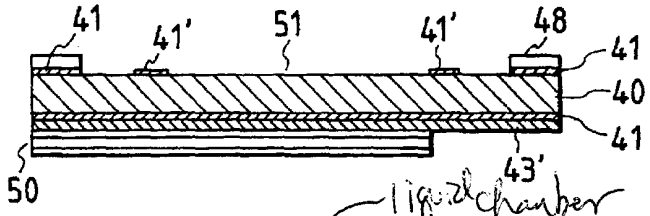

FIG. 5(e)

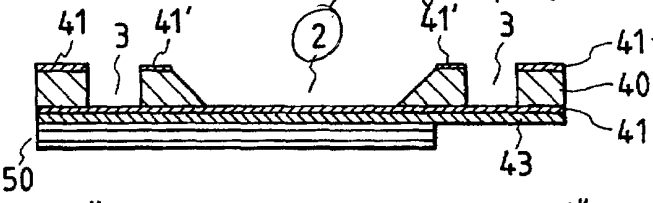

FIG. 5(f)

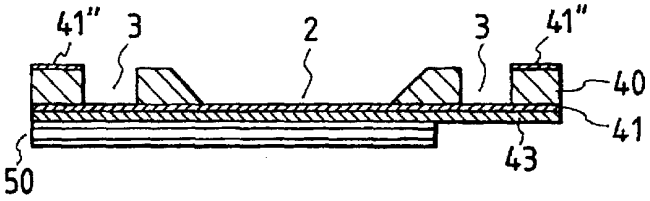

FIG. 5(g)

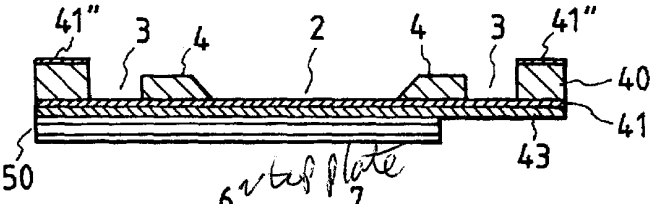

FIG. 5(h)

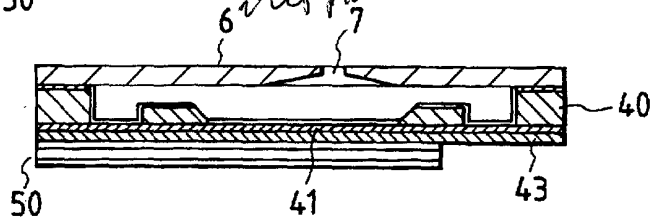

FIG. 7(a)

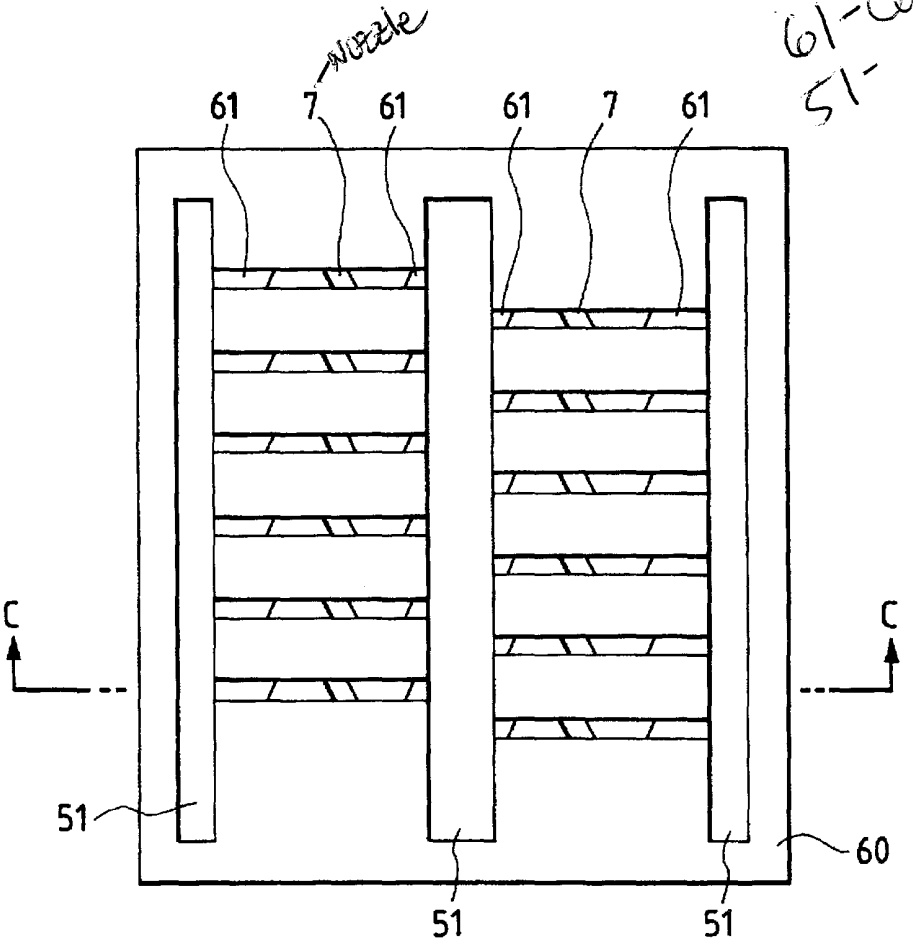

FIG. 7(b)